Mo. 23

1963

avoiding the use of engineering elements as the basis of a physical theory. We postulate the existence of a function S of the thermodynamic variables of a composite system that will always increase when spontaneous thermal, mechanical, and diffusive interactions take place between the components of the composite system. By introducing a limiting spontaneous process (reversible process), in which the increase of S is 0, and 2 special thermodynamic systems (perfectly insulated weight and infinite heat reservoir) to be used as components in a reversible process, we can prove that the change of S of a single thermodynamic system due to any spontaneous process equals $\delta Q/T$ along a reversible process, thus identifying S to entropy. The differences between this approach[1] and others is also discussed.

[1] Details may be found in *Foundations of Thermodynamics* (Oxford University Press, to be published).

Tuesday Afternoon at 2:00

Empire State Room, Statler–Hilton

(D. F. Hornig presiding)

Fluid Dynamics II

Mo. 23

Q1. Ablation of an Insulator by a Current Parallel to its Surface.* James Keck, *Avco-Everett Research Laboratory.*—Measurements of the shock speed in an unbiased magnetic annular shocktube of large radius ratio have been made, which indicate that most of the material accelerated comes from ablation of the insulator at the driver end of the tube. A model of the ablation process has been developed based on the assumption on a thin quasisteady MHD boundary layer on the insulator in which a current flows parallel to the surface. This current gives rise to both Joule heating, which causes the ablation, and a $j\times B$ force, which accelerates the ablated material away from the insulator. The conditions existing in such a boundary layer and the factors effecting the ablation rate are discussed semiquantitatively.

* Work sponsored by the U. S. Air Force Office of Scientific Research.

Q2. Experiments with Magnetohydrodynamically Supported Shock Layer. H. E. Petschek, E. V. Locke, and P. H. Rose, *Avco-Everett Research Laboratory.*—Experiments have been performed to determine the interaction of a hypersonic flow with the field of a current-carrying wire as analyzed by Levy and Petschek.[1] The analysis predicts that at low electrical conductivity a thin shock layer will exist concentric with the wire at a position determined by setting the interaction parameter, based on the velocity behind the normal shock and a distance of ϵ times the shock radius, equal to $[1+(2\epsilon)^{\frac{1}{2}}]/3$ where $\epsilon=\rho_1/\rho_2$. Experiments were performed in air in an electrically driven shocktube with shock velocities of about 8 mm/sec and initial pressure of 250 μ. Data have been obtained by observing the flow luminosity, using an image converter and mirror camera looking both perpendicular to and along the wire. Steady flows were observed throughout most of the homogeneous test gas. A shock front was observed to stand up to 3 cm in front of a wire of 0.3-cm radius, carrying currents of up to 300 000 A. The data show the general characteristics indicated by the theory and yield quantitative agreement on the location of the shock layer within 50%.

[1] R. H. Levy and H. E. Petschek, Phys. Fluids (to be published).

Q3. Measurements of Nitrogen and Argon Shock Thickness.* Morton Camac, *Avco-Everett Research Laboratory.*—Experimental shocktube studies have been started to measure the density variation in shock waves, in both the translational and rotational portions. A 24-in.-diam shocktube is used to obtain initial pressures of argon and nitrogen in the range from 10–50 μ Hg. The density variation of the gas is measured by the single scattering intensity of a high-energy, well-collimated electron (60–120 keV) beam. The beam collimation remains less than $\frac{1}{2}$ mm diam at 3 in. from the gun. The single scattering intensity in the angular range from 15°–30° is sufficient to obtain microsecond measurements for a several-microampere incident beam. Only electrons scattered from a $\frac{1}{2}$-in. length of the beam are used for the measurements in order to minimize the effects of the shock-front curvature (up to 2 cm in the 24-in. tube).

* Work supported jointly by the U. S. Air Force Systems Command, and by the Advanced Research Projects Agency, monitored by the U. S. Army Missile Command.

Q4. Shocktube and Flame Diagnostics by Ion Probes.* W. C. Taylor, H. S. Rothman, and T. Morita, *Stanford Research Institute.*—Wire probes biased for positive-ion collection are known[1] to offer a simple means of inferring ion and electron density in plasmas with excellent spatial resolution and dynamic range but with questionable accuracy, depending upon probe radius r, mean free path λ, Debye length, and fluid-dynamic conditions. Experiments were performed in both an electromagnetic shocktube and in low-pressure hydrocarbon flames to simultaneously diagnose these plasmas by means of ion-probe and microwave-transmission measurements. Under one set of conditions, the probe results agreed with the microwave measurements within 20% and agreed within a factor of 3 under all conditions tested. Accuracy appears almost independent of λ if $r\lesssim\lambda$, and is independent of flow velocity up to at least 8 mm/μsec. Probe response times lower than 0.1 μsec were typical.

* Work supported by Advanced Research Projects Agency.
[1] D. Bohm, E. H. S. Burhop, and H. S. W. Massey, in *Electrical Discharge in Magnetic Fields*, edited by Guthrie and Wakerling (McGraw-Hill Book Company, Inc., New York, 1949), Chap. 2

Q5. Directional Effect of Charge Motion on Shock Formation at a Spherical Pentolite Charge. Henry J. Goodman (introduced by Jane M. Dewey), *Aberdeen Proving Ground.*—The peak pressure at interaction of the explosive and ballistic shock in the direction of charge motion is estimated from hydrodynamic theory. Approximations to the flow conditions and shock propagation along this direction are made. The increase in peak pressure at the forward point of the ballistic shock varies from about 30% at charge velocity Mach 1.5 to about 150% at Mach 10. Comparison of differing approximations indicates that the major part of the increase results from pressure and entropy change within the ballistic shock rather than from the air flow about the charge.